LOW TEMPERATURE EVALUATION OF THE LTC1799 OSCILLATOR

Test Report

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Background

The Linear Technology LTC1799 is a precision oscillator whose frequency is programmable in the range of 1 kHz to 20 MHz by a single external resistor (RSET). A built-in feedback loop provides a linear relationship between the frequency and RSET. The device has high accuracy and can be driven with a single 2.7 to 5.5V power supply providing a 50% duty cycle square wave output. It has a CMOS output driver that insures fast rise/fall times and rail-to-rail switching [1].

Test Setup

Two circuit boards, each populated with an LTC1799 chip, metal film resistor (RSET), and a 0.1 µF COG ceramic bypass capacitor, were designed and built for evaluation in the temperature range of +25 °C to -190 °C. The LTC1799 devices were industrial grade with a specified operating temperature range from -40 °C to +85 °C. The values of RSET chosen for circuit board 1 and circuit board 2 were 10 kΩ, and 9.09 kΩ, respectively. This resulted in oscillator frequencies of 10 MHz for circuit board 1 and 11 MHz for circuit board 2. This was done due to the need of an precision oscillator with output frequency between 10 and 11 MHz.

With a supply voltage of 5 V, the two circuit boards were evaluated at several temperatures from room to about liquid nitrogen temperature. At each test temperature, the circuit boards were allowed to soak for about 15 minutes before any measurements were made. This ensured that all components mounted on the circuit boards have attained thermal equilibrium. Performance characterization included supply input current, and oscillator output frequency and waveform. A digital oscilloscope was used to capture the output waveform and a frequency counter was utilized to measure the oscillator output frequency.

Results and Discussion

The oscillator output frequency for both devices are shown as a function of temperature in Figure 1. The test temperatures at which data was taken were 25; 0; -25; -50; -75; -100; -125; -150; -175; and -193 °C. Both devices exhibited a gradual decrease in output frequency as temperature was decreased. At -100 °C, for example, this decrease in frequency amounted to 1.7% and 1.2% for device 1 and device 2, respectively. At the extreme lowest test temperature, namely -193 °C, the output frequency of device 1 decreased by 5.6% while that of device 2 decreased by 3.5% from their room temperature values. This change in frequency with temperature in the range of 25 °C to -40 °C seems to agree with that of the device specifications. These integrated circuits are specified by the manufacturer to have a ± 40 ppm/°C temperature stability with operating temperature range of -40 °C to +85 °C.

The oscillator output peak-to-peak voltage (Vp-p) and supply input current (Is) at various temperatures are listed in Table I. Significant increase in both parameters was observed as temperature was decreased. While the increase in the supply current can be attributed to changes in the characteristics of the device with temperature, the reasons for the increase in the output voltage signal can not be easily explained. It can be postulated, however, that parasitic resistive and capacitive effects associated with the long leads, that provided connection to the scope and frequency counter, in conjunction with the temperature-induced changes inherent to the device, might have lead to some resonance.

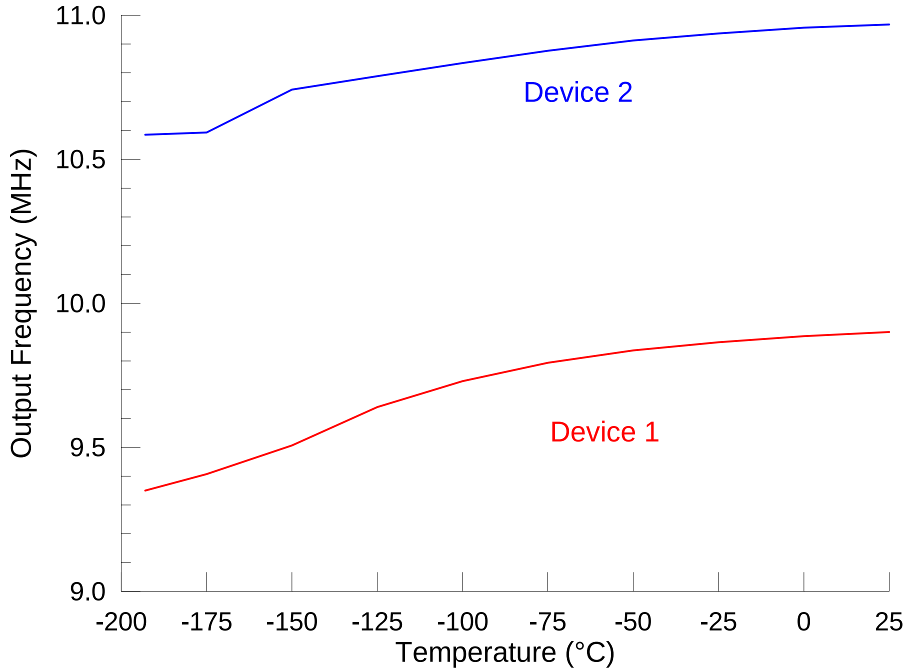

Figure 1. Oscillator output frequency for both devices as a function temperature.

Table I. Oscillator output voltage and supply input current versus temperature.

	Device 1		**Device 2**	
Temperature (°C)	**Vp-p (V)**	**Is (mA)**	**Vp-p (V)**	**Is (mA)**
25	4.48	15	4.36	15
0	4.84	15	4.68	16
-25	5.24	16	5.04	17
-50	5.64	17	5.4	18
-75	6.04	18	5.84	19
-100	6.52	19	6.3	20
-125	6.96	20	6.72	22
-150	7.36	21	7.2	23
-175	7.56	20	7.52	23
-193	7.76	21	7.76	24
25	4.52	15	4.4	15

Although the specified supply current for these devices should be about 2.4 mA at room temperature with no load, the values of this property for both devices listed in Table I far exceed that level. This is apparently due to the loading effect introduced by both the oscilloscope and the frequency counter. At room temperature for example, when the frequency counter was disconnected from the circuit, the supply current, for either device, dropped from 15 mA to 9 mA. In addition, the long leads connecting the oscilloscope and frequency counter added some resistive loading to the device under test. The combined loading effect of the long leads and the monitoring instruments might have exceeded the drive capability of the device output.

The oscillator output waveforms under various conditions for both devices are shown in Figures 2 and 3. These waveforms are shown at 25 °C and -193 °C for both cases where the frequency counter, which was used to measure the output frequency, was either connected or disconnected from the circuit setup. It can be clearly seen that by connecting the frequency counter to the circuit under test, for either device, introduces loading effect as reflected by the oscillator output waveform distortion. This behavior occurs regardless of the test temperature. As far as temperature is concerned, the oscillator output frequency decreases, as mentioned before, as temperature is decreased. In addition, the output voltage signal amplitude tends to increase with decrease in temperature. As mentioned before, this anomaly may be attributed to parasitic factors and component-related changes induced by the low temperature.

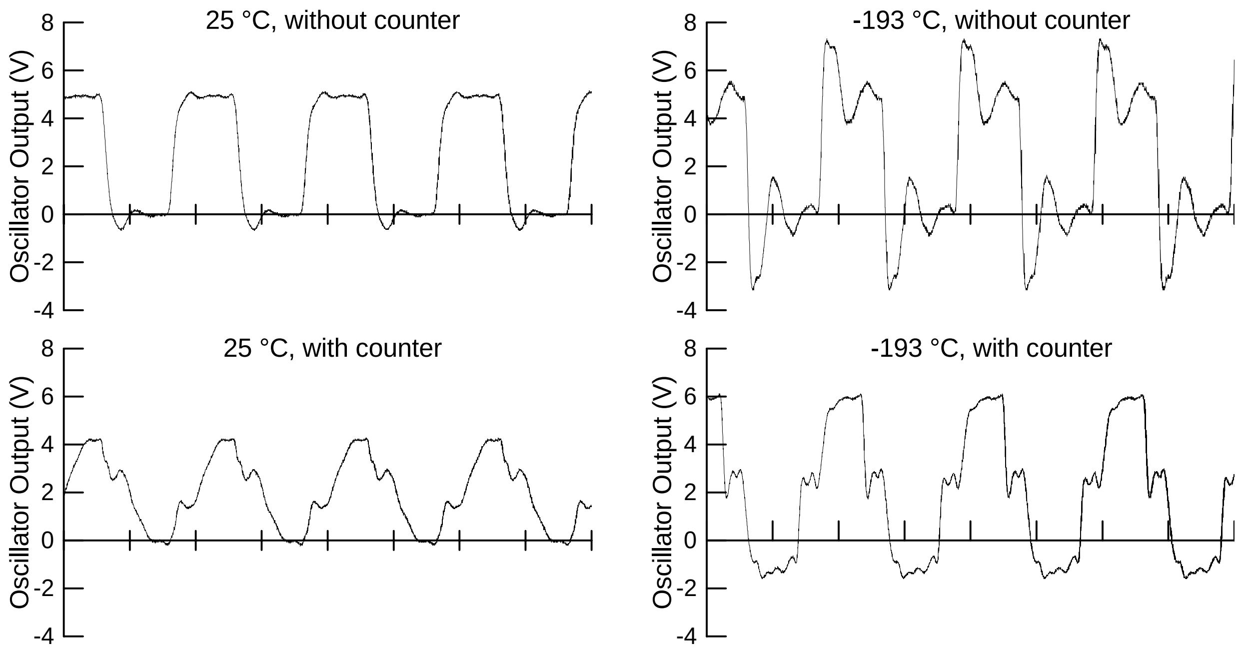

Figure 2. Device 1 output waveform under various conditions (time scale: 50 ns/div).

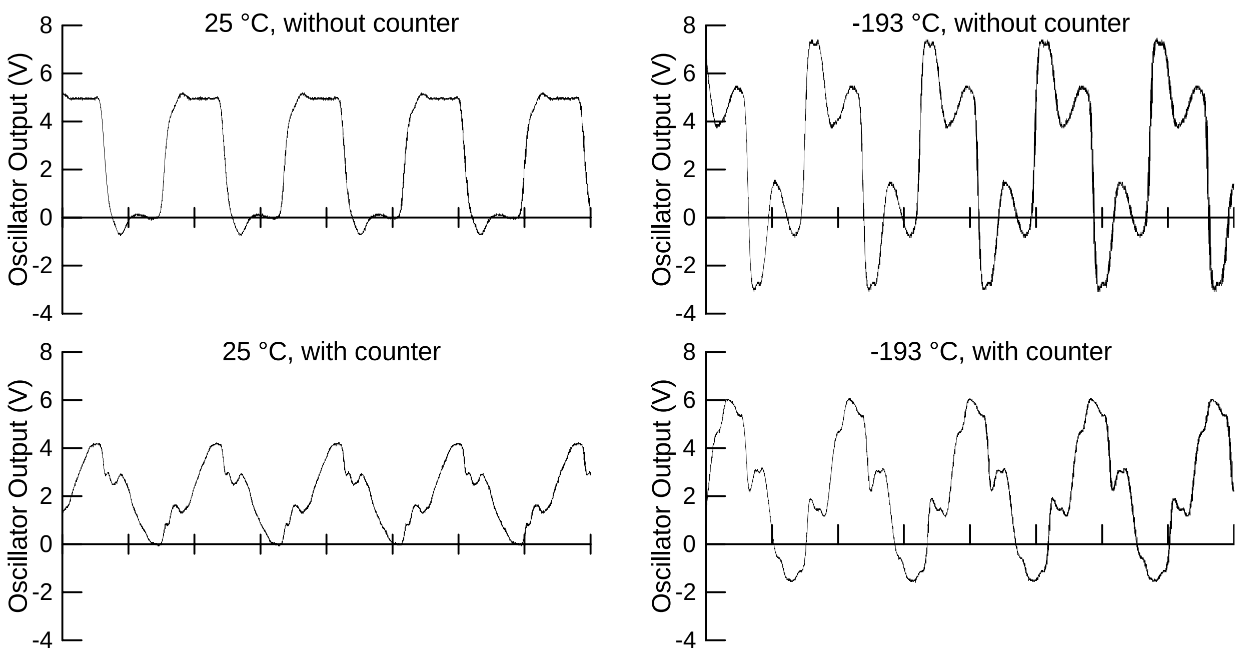

Figure 3. Device 2 output waveform under various conditions (time scale: 50 ns/div).

In order to establish a better understanding of the effect of low temperature on the performance of these oscillators, device 1 was subjected to further testing with the purpose of eliminating as much noise and loading effect as possible. A circuit board was utilized where extremely short connecting leads were used among the on-board components, the power supply, and the output monitoring instrument (digital scope). The frequency counter was excluded from this setup. This board was characterized at room temperature and at -196 °C. This was achieved by dunking the board in a liquid nitrogen-filled dewar for about 15 seconds.

The resulting peak-to-peak output voltage, oscillator frequency, and the input supply current are shown in Table II. Although the peak-to-peak voltage increased significantly, as was the case for the previous setup, the frequency of the oscillator, on the other hand, did not exhibit any appreciable change. Also, the supply current maintained its values at both test temperatures. These values were much lower than those when the frequency counter was connected to the circuit. This result confirms that the frequency counter, when connected to the circuit, somehow influenced the output of the oscillator circuit.

Table II. Device 1 output parameters and supply input current versus temperature.

Temperature (°C)	Vp-p (V)	Frequency (MHz)	Is (mA)
25	6.0	9.930*	5
-196	9.1	9.927*	5

* As measured by digital oscilloscope.

A closer examination at the output waveforms, shown in Figure 4, once again demonstrates the effect of loading on the oscillator circuit, i.e. the signals obtained at both temperatures were cleaner and without much distortion introduced. In addition, the average value of the oscillator output voltage remained relatively the same. The significant increase in the peak-to-peak value of this parameter, which was mentioned earlier, is however resulting from the appearance of an overshoot at the rising edge of the output waveform. This event, which takes place at -196 °C, is probably due to device intrinsic changes with temperature.

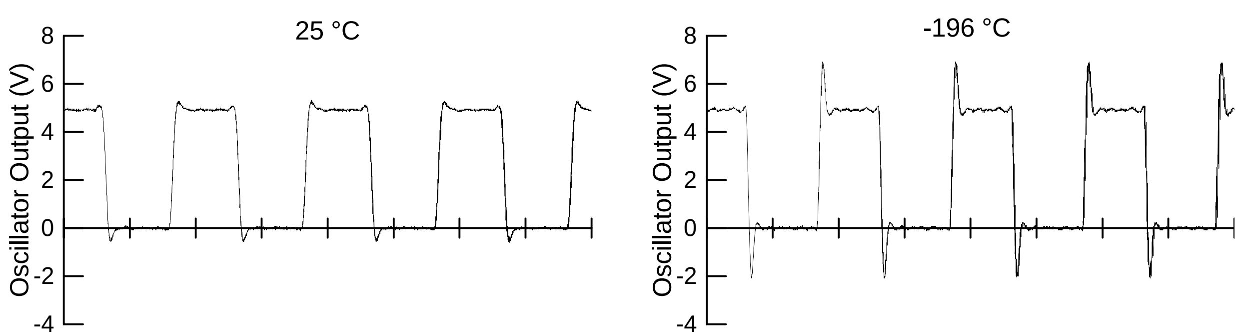

Figure 4. Device 1 output waveform at 25 °C and at -196 °C (time scale: 50 ns/div).

Conclusion

Two devices of the Linear Technology LTC1799 precision oscillator have been evaluated for potential use in low temperature applications. These devices were industrial grade with a specified operating temperature of -40 °C to +85 °C. The results from this preliminary work indicate that these devices may be capable of operation at low temperatures beyond their manufacturer's specification. Although the present work has shown good operational behavior of these devices with temperature in the range of +25 °C to -196 °C, proper circuit layout and good component selection combined with long term comprehensive characterization are needed to establish their potential use and reliability for extreme temperature applications.

References

1. LTC1799 Data Sheet, Linear Technology Corporation.

Acknowledgments

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